Review Article

Positioning of the implants considering the balance of the teeth in the dental arches: a review

Abstract

The human body is the most portrayed and studied object in history. Though familiar, it is instinctively attractive and eternally fascinating. We in dentistry study the engineering of the masticatory system, responsible for keeping this body alive, communicative, smiling and expressing all its feelings. The teeth together play the functions of mastication, protection and support of related soft tissues, assist in the articulation of words and are an important factor in the aesthetics of the face. The teeth comprise the incisor, canine, premolar and molar groups, each adapted to the masticatory functions of learning, cutting, tearing and crushing solid foods. Therefore, knowledge of the direction of the teeth is of great importance in implant clinics for the correct installation of the implants, which are very important for the maintenance of the balance of the forces exerted by mastication muscles (masseter muscle, temporal muscle, medial pterygoid muscle). In addition, evaluation of the amount and density of bone available at the patient's toothless site. This available bone represents the amount of bone in the edentulous region considered for implant installation; this is measured in width, height, length, angulation, crown height space, and bone density.

Keywords: implants, implants position, balance of teeth, dental arch

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Introduction

Oral rehabilitation with osseointegrated implants has quite high success rates.[1,2] According to the protocol established by Branemark, with a two-stage surgical procedure, a success rate of 95.0 % to 99.0 % was observed over a ten-year period. However, the biomechanical behavior of dental implants is different from natural teeth due to the fact that they do not have a periodontal ligament; thus transmitting the masticatory loads directly to the supporting bone.[2] This characteristic of distribution of the loads directly to the bone tissue has the consequence of the modification of the tissues adjacent to the implant; among them, the bone tissue, which undergoes a modification to the establishment of new biological distances, which includes bone resorption. If excessive loads are applied to the osseointegrated implant, this bone resorption will be accentuated.[3] The emergence and application of the principles of osseointegration in dentistry enabled new horizons for oral rehabilitation of partial and total edentulous patients. The term osseointegration was defined as "a structural and functional connection between the bone base and the surface of an implant under functional load",[4] suggested by several researchers and later studied by Brånemark et al. Currently, after decades of *in vitro* and *in vivo* experimental studies, osseointegrated dental implants have reached a stage of scientific verification that enables their use in oral rehabilitation, with expressive success rates verified in the most varied restorative situations.[4]

Studies have confirmed this positive correlation between occlusal overload and bone resorption in osseointegrated implants.[4,5] Thus, every effort must be made to understand the distribution of the loads in the prosthesis/implant system and bone tissue, in order to allow the establishment of an adequate three-dimensional positioning of the implant, avoiding excessive loading and treatment failure 5. The three-dimensional positioning of the implant is also closely related to the success of the aesthetic result of implant-supported rehabilitations. Among the criteria considered for the success of rehabilitations with dental implants is the establishment of soft tissues with adequate contour, gingival profile and the presence of interproximal papillae.[6] The great advance of dentistry associated to the appearance of osseointegrated implants is based on the possibility of producing support for prosthetic restorations in areas where no dental elements or residual roots are found.[6,7] This undoubtedly generated an unparalleled opportunity to improve the aesthetic-functional performance of patients who, by the absence or unfavorable distribution of dental elements, had as their only alternative restorative partial dentures or total dentures. In addition, other partial edentulous patients, such as cases of unitary edentulism, may also benefit from osseointegrated implants when it becomes unnecessary to use remaining teeth, often healthy, as a support for prosthetic restorations, eliminating tissue removal sound dental.[8] Clinical research of several osseointegrated implant systems published in the dental literature has shown that the longitudinal success rates of implants increase proportionally to the development of new components and surgical-restorative techniques, which justifies their gradual increase in clinical application in oral rehabilitation.[9,10] The objective of this study was to present the main literary findings on the balance of dental arch implants.

Methods

Experimental and clinical studies were included (case reports, retrospective, prospective and randomized trials) with qualitative and/or quantitative analysis. Initially, the key words were determined by searching the DeCS tool (Descriptors in Health Sciences, BIREME base) and later verified and validated by MeSh system (Medical Subject Headings, the US National Library of Medicine) in order to achieve consistent search.

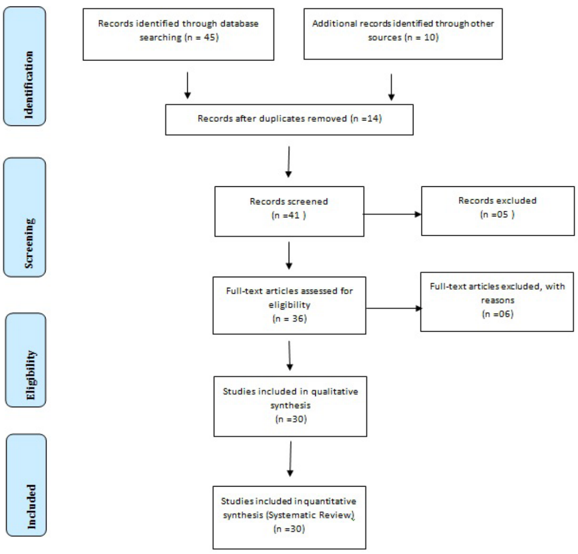
Mesh terms

The words included were *Implants. Implants Position. Balance* *of Teeth. Dental Arch.* For further specification, the *Dental implants* description for refinement was added during searches. The literature search was conducted through online databases: Pubmed, Periodicos.com and Google Scholar. It was stipulated deadline, and the related search covering all available literature on virtual libraries.

Series of articles and eligibility

A total of 45 articles were found involving *implants*. Initially, it was held the exclusion existing title and duplications in accordance with the interest described this work. After this process, the summaries were evaluated and a new exclusion was held. A total of 32 articles were evaluated in full, and 19 were included and discussed in this study.

Flow chart



Literature review

Understanding the surface types of osseointegrated implants and their macro and microscopic characteristics is of paramount importance for the success of clinical treatment, due to the direct consequences of the external characteristics of the implants in the osseointegration process.[1–3] The mechanisms of adhesion and production of the calcifiable organic matrix of osteoblasts on the surface of the implants are directly influenced by microscopic conditions inherent to the biomaterial, such as surface tension, surface texture and chemical composition, as well as macroscopic, such as implant morphology.[4] Microscopic features of biomaterials such as surface tension and chemical composition will not be addressed in this chapter as they are practically defined and detailed in various materials engineering publications. However, some innovations in the surface aspects of implants introduced in recent years deserve some consideration.[5,6] The vast majority of commercially available osseointegrated implant systems consist of a metal base with or without a special surface treatment.[7–10] During the preparation of the implant, its macroscopic design is designed and later executed through machining or cutting of the metal.[10] The machining process, while providing a smooth clinical appearance surface, characterizes in the metal small surface grooves that are maintained in the fabricated implant. It is important to note the formation of a surface layer of oxides, already mentioned above, when cutting the pure metal or metal alloy. According to some authors, the chemical stability, composition and thickness of this layer is of fundamental importance during the obtaining and maintenance of osseointegration.[11]

Regarding external characteristics, the surfaces of metal osseointegrated implants are more commonly found in four types: smooth, already described previously in the machining process; blasted, with an abrasive powder or through the TPS (Titanium Plasma Spray) process; acid-conditioned; and, finally, covered with some ceramic material. The basic objective of any process is to seek a greater area of surface contact between the bone base and the implant, in addition to providing a better bed for the osteoblastic cell to achieve adhesion to the biomaterial and consequent production of collagen matrix.[11] In this particular adhesion, it is known that the osteoblastic phenotype cell adheres more easily and produces its specific protein when in contact with a rough surface compared to a smooth surface.[11] In the process known as TPS, small titanium particles are heated at high temperatures and blasted onto the surface of an already prepared implant. The impact of these heated particles against the surface of the implant causes them to deform and consequently melt the surface metal, forming a shell or a blasted layer around the implant.[12] The surface acid etching method lately has been employed on a larger scale by manufacturers of implant systems. In this method, chemical compounds with different concentrations are employed in the acid conditioning of the metal surface of the implant. This acid conditioning forms surface microdepressions, increasing the total surface area and characterizing the receptor bed of osteoblastic cells.[13] However, there is still no consensus in the dental literature regarding the concentration and time of optimal application of the acid on the surface of the implant. It is known, however, that the size of these microdepressions produced decisively affects the mechanisms of adhesion and production of proteins of these osteoblastic cells. Finally, we have the method of ceramic covering of metal implants. This coverage is done in different ways following the technique adopted by each manufacturer. Generally, for the synthetic hydroxyapatite coatings, the plasma spray process is used where particles of the ceramic material are heated at high temperatures and sandblasted on the surface of a metal implant. Various other techniques of applying ceramic coverings have been described, such as, for example, radiofrequency blasting, but with similar characteristics in terms of the surface produced. The new trends of manufacturers of dental implant systems regarding surface treatment and implant design are well diversified. Some implant systems use both machining and acid etching techniques, while still blending with abrasive oxide, creating a set of macro and surface microstrips. This set is said to be more amenable to osseointervention by manufacturers who use it, although research may differ on definitive answers on the best surface for use in Implantology. Still, a new method of surface texturing for dental implants was introduced commercially, constituted by electrochemical corrosion. Allowing the thickness control of the oxide layer formed, this process is characterized by the manufacturer as applicable to dental implants due to the excellent cellular response found in preliminary animal studies. The generated surface has a characteristic aspect, similar to a marine coral. However, it is emphasized that any modification of implant characteristics, even if apparently of lesser expression, will certainly influence positively or negatively the osseointegration process and, consequently, its clinical success. The evaluation of the performance of these modifications in in vitro and in vivo research is of paramount importance before a commercial

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launch, a procedure that is often abandoned by some manufacturers.[14]

The Biology of bone repair Basic conditions that will promote osseointegration or functional ankylosis around the implants have been described in the dental literature. This bone healing is conditioned to: - Local cellular condition; - Vascular condition; - Nature of the stimulus in the region.[15] The cell response of interest in osseointegration occurs through 3 specific cells: the osteoblast, the osteocyte and the osteoclast, the first two with the role of production and maintenance of the bone matrix and the last with the function of bone resorption remodeling. Also important are undifferentiated mesenchymal cells, which can differentiate into cells of osteoblastic phenotype and ensure the production of calcifiable collagen matrix (type I or II) on the surface of the implant.[16] The vascular condition at the operated site will promote the nutrition necessary for these cells to perform their specific functions. Also, by the release of specific proteins (growth factors) during the cicatricial process, one can observe the renewal of the blood supply in the operated region through vascular neoformation or angiogenesis.[16] As for the stimulation in the operated region, it is known that the bone in post-trauma repair can not receive load beyond a physiological threshold of tolerance, under penalty of induction to a process of cicatricial fibrosis.[17] Therefore, there is a need to preserve this bone-implant interface of excessive loads in initial healing periods, especially at times involving cell differentiation. The question of what would be the tolerable load threshold applied on the implant without inducing fibrosis formation and what is the optimal time for the start of the application of this load remains under investigation.[17] Certainly, there is no absolute response for all cases, since this functional load received by the bone-implant interface will depend on factors such as total interface area, bone quality in question, size of the implant used and amount of load distributed to each restoration implant.[17] This issue, however, is of fundamental importance for the success of the application of immediate loading to implant-supported prostheses.[17,18] Bone quality and quantity Two anatomical aspects of the bone region to be operated are of fundamental importance for the prognosis of the implants and consequently of the implant-supported prosthesis: the quantity of bone available and the quality of this bone at the implantation site. The amount of bone in a given region of the maxillary arches determines the length and diameter of the implants to be used. It is directly related to aspects such as alveolar ridge area to be operated and presence of anatomical structures in the region.[19] Regarding the degree of resorption, the bone quantity is directly influenced by the total period of edentulism, factors intrinsic to the patient and prolonged use of muco-supported prostheses. These factors, often combined, act directly to influence the degree of bone resorption in the implantation area. Results of several published studies point to a higher success rate for implants with greater area of contact with the bone base, a direct consequence of the diameter and length of the implants used.[19] Bone quality can be determined by the clinical evaluation of the thickness of the cortical bone and the density of the bone trabeculation in the area receiving the implants. Presence of a border with purely cortical bone is classified as type I; type II has a thick cortical bone and dense trabecular border; type III presenting fine cortical with dense bone trabeculate and, finally, type IV with thin cortical bone and rare trabeculate.[2,3] The presence of a type IV bone with thin cortical and rarefied trabecular bone, a condition usually found in posterior areas of the maxilla, impose a situation of difficult to obtain primary stability of the implant after surgical insertion. Consequently, an unfavorable condition regarding the prognosis of the implant is established. Already a thick cortical condition and dense bone trabecula, usually found in the anterior jaw zone, allows a greater stability for the implant. However, it is not uncommon for the purely cortical bone bed to represent an unfavorable condition as to the blood supply of the cells of the bone-implant interface, which may compromise osseointegration of the implant even under very favorable conditions of primary stability.[3,4] The radiographic resources added to the local observation in the trans-operative are applied in determining the amount of bone in the operated area.[4] However, the determination of bone quality is still subjective, since it relies on the tactile sensitivity of the surgeon during the first moments of the bone base perforation. Attempts to correlate bone density values obtained with computed tomography and bone quality were described in the literature, but still with little clinical applicability.[5] Implants equipped with sensors capable of estimating bone quality by measuring the drilling resistance of the drill during the preparation of the surgical alveolus are already commercially available, but with few studies attesting to its actual efficacy.[6] The position of the implant optimizing esthetics numerous are the fundamental factors for the good esthetic performance of an implant-supported prosthesis. We can cite as main the general conditions of the soft tissues, the amount of bone and the location and inclination of the implant placed. The correct positioning of the implant is related to the location and axial inclination of the implant, aiming to favor the emergence profile and aesthetic contours of the prosthesis.[7] For correct placement of the implant in the edentulous ridge, it is necessary for the surgeon to visualize the three-dimensional position of the implant during the operation and its future relationship with the prosthesis to be made.[6–8] For this, even for professionals with extensive experience in dental implant surgery, it is important to use a surgical guide that faithfully represents the final position of the dental crown to be manufactured. Both the buco-lingual and the mesio-distal inclination of the implant will influence the contours of the future prosthesis as well as the aesthetics of soft tissues, especially in the region of the interdental papillae.[9] In this sense, the ideal location of the implant would be that assumed by the lost dental root. Also, the location of the height of the cervical portion of this implant relative to the adjacent teeth is important for determining the prosthetic space available for the restoration, as well as its emergency profile and surrounding soft tissue biological space.[1,2] Each implant system, because it has different characteristics of connection between components and cervical design, presents values of ideal distances for the creation of a correct prosthetic restoration profile.[3] However, as a general rule, for two-stage implants, it is recommended that the level of the cervical surface of the implant be located at 2.0 to 3.0mm to apical of the amelo-cemental border of neighboring teeth.[4] Distances between implants should, on average, present a minimum of 3mm of available space for development and adequate nutrition of the gingival papilla, as well as adequate bone quantity. Already distances between tooth and implant, by the presence of cortical bone surrounding the alveolus and bone crest to support the periodontal soft tissues, a space of 1.5mm seems to meet the esthetic-functional needs.[4,5] The positioning of the implant optimizing function during the 1990s, several concepts of structural calculation applied routinely in engineering were introduced in Implantology.[6] Having a prosthetic structure with a certain degree of flexibility, anchored in implants with no clinical mobility, under which masticatory loads will be generated generating several force vectors, it is understandable that the prognosis of this restoration is closely related to the biomechanical behavior of this restoration, in aspects of transfer of physiological loads from the implant to the bone base. In single-piece dentures implants, there are no variations to optimal implant placement for biomechanical optimization.[7]

The unit implant should ideally follow the location and angulation of the lost tooth root.[8] One option to allow a better distribution of loads to the implant-adjacent bone in posterior areas would be the choice of two implants to replace one molar or the use of large diameter implants (5.0mm or 6.0mm) when bone-implant contact surface and favoring the distribution of loads to the adjacent bone.[9] In an implant-supported partial denture we have the direct effect of the positioning and angulation of the implants in the distribution of the masticatory loads to the bone base.[9] There are descriptions in the dental literature where the reduction of forces transferred to the bone adjacent to the implant can be doubled in the case of a partial denture of three elements with two implants with anterior cantilever extension, and this same force can be reduced to a third if it eliminates the cantilever is added by adding an implant in the place, positioning the implants in tripoidal (non-aligned) form.[10] This concept can also be applied in implanted fixed total rehabilitations, as planes or polygons form between implants distributed anteriorly posteriorly in the maxillary arches.[11]

Conclusion

Therefore, it seems fundamental from the functional point of view that the implants are forming a polygon with each other for a greater anchorage and stability of the prosthesis during the masticatory function. It is up to the professional during the surgery to be aware that the distribution/angulation of the implants are as important as the number and position of the implants in the maxillary arches.

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Conflict of interest

The authors declare that there is no conflict of interest.

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